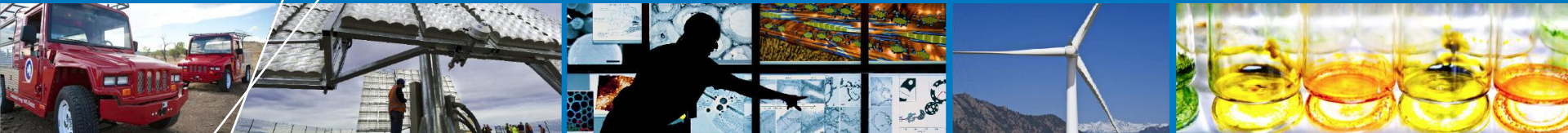
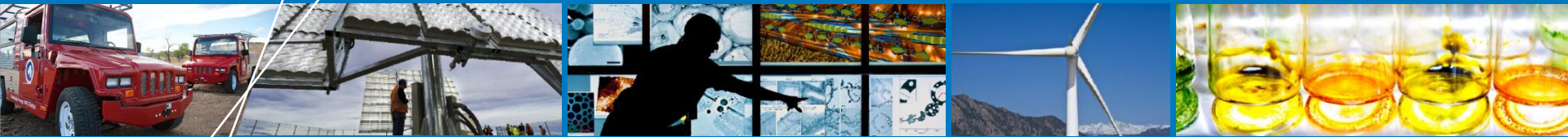


Eastern Renewable Generation Integration Study



April 8, 2013

Thermal Generator Properties



Thermal Generator Characteristics

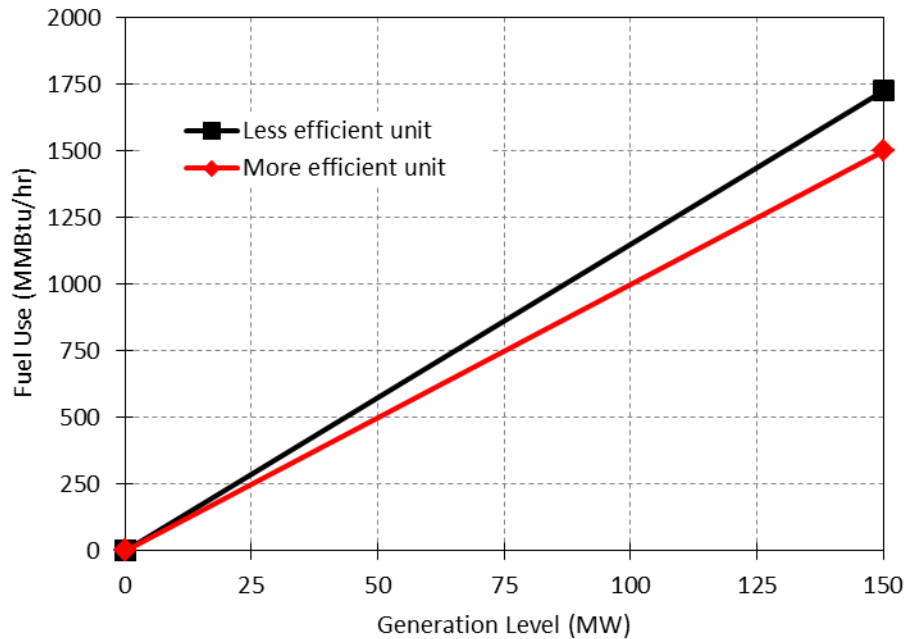
- **EIPC assumptions**
 - Part-load heat rate shapes
 - Min up/down times
 - Ramp rates
 - Forced and planned outage characteristics
- **Non-EIPC assumptions:**
 - Unit-specific FLHR from EPA CEMS data
 - Startup and VO&M costs from Intertek APTECH

EIPC Thermal Assumptions

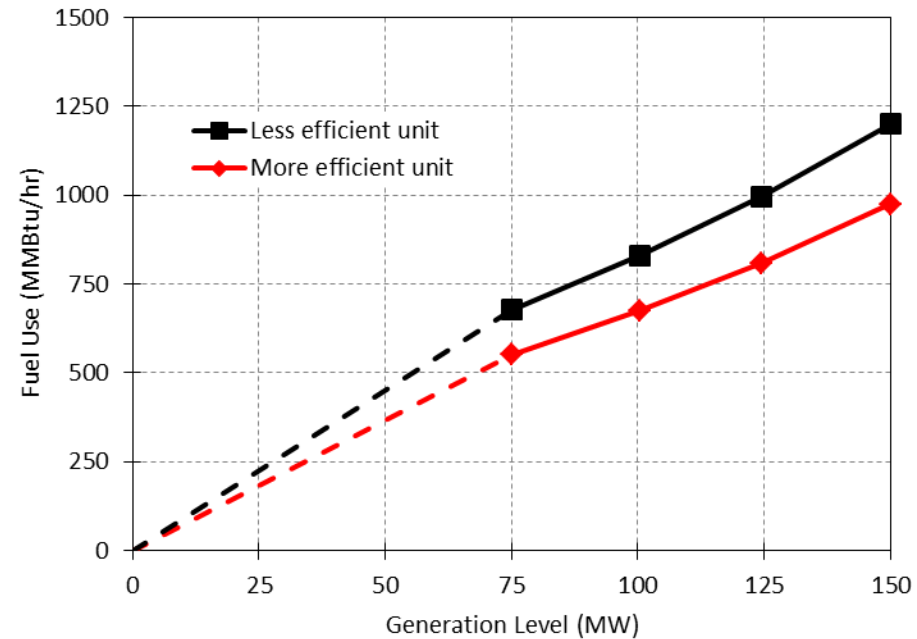
Category	Marginal Heat Rate (% of Max Capacity / % of FLHR)				Minimum Up Time (Hours)	Minimum Down Time (Hours)	Startup Costs (\$/MW)	Ramp Rate (MW/min)
	Step 1	Step 2	Step 3	Step 4				
CT	100% / 100%				1	1	0	
CC	50% / 113%	67%/ 75%	83% / 86%	100% / 100%	6	8	35	10
Coal_ST < 600MW	50% / 106%	75%/ 90%	100% / 100%		24	12	45	3
Coal_ST > 600MW	30% / 110%	50% / 93%	75% / 95%	100% / 100%	24	12	45	3
Oil/Gas_ST < 600MW	30% / 110%	50% / 90%	75% / 96%	100% / 100%	10	8	40	6
Oil/Gas_ST > 600MW	20% / 110%	50% / 95%	75% / 98%	100% / 100%	10	8	40	6
Nuclear					168	168		

Example Generator Fuel Use Shapes

Combustion Turbine

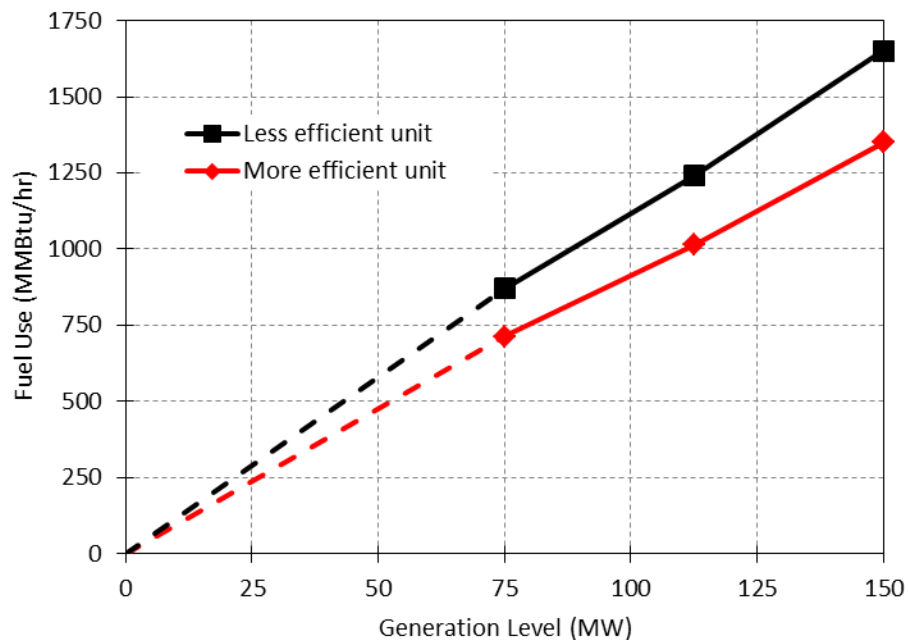


Combined Cycle

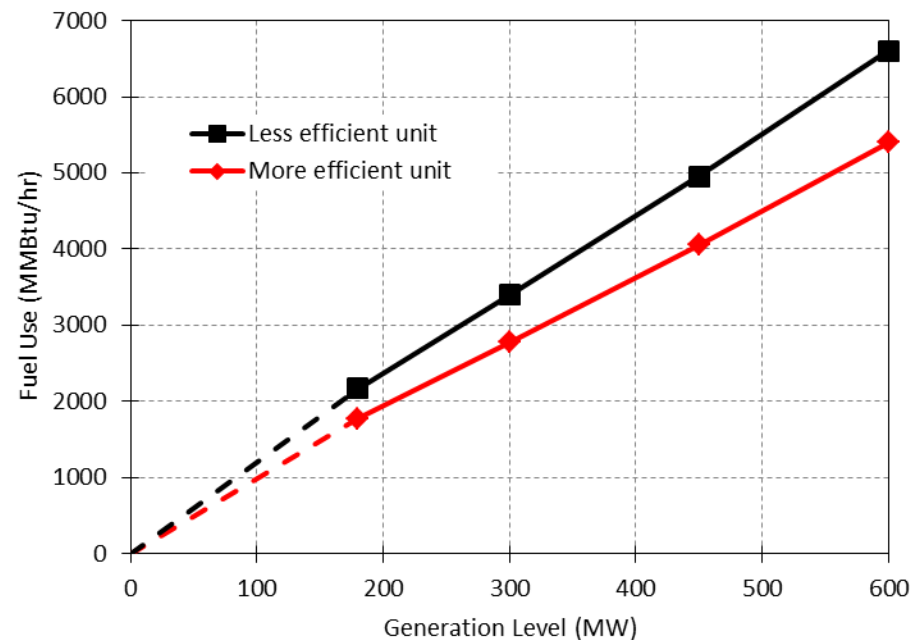


Example Generator Fuel Use Shapes

Coal < 600 MW

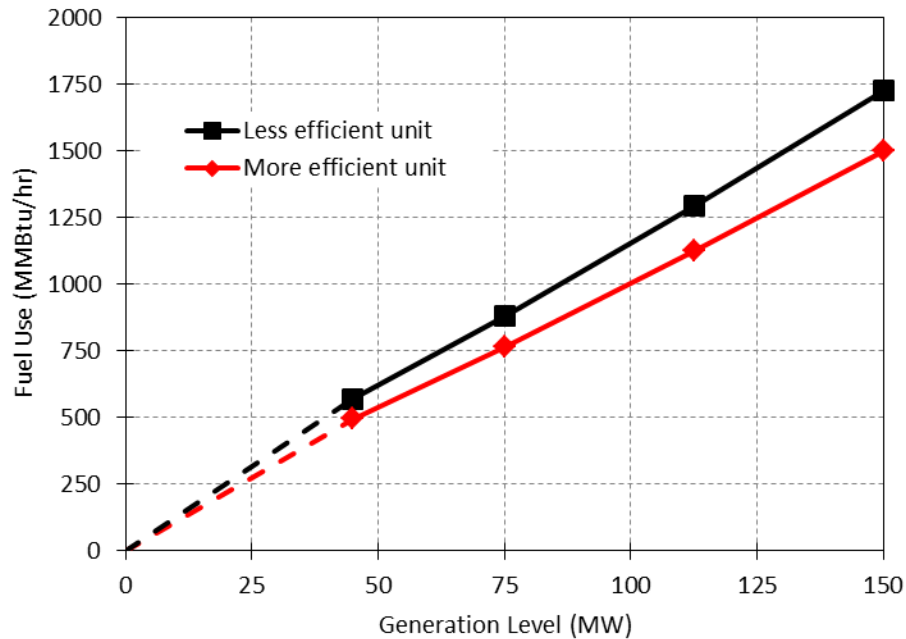


Coal > 600 MW

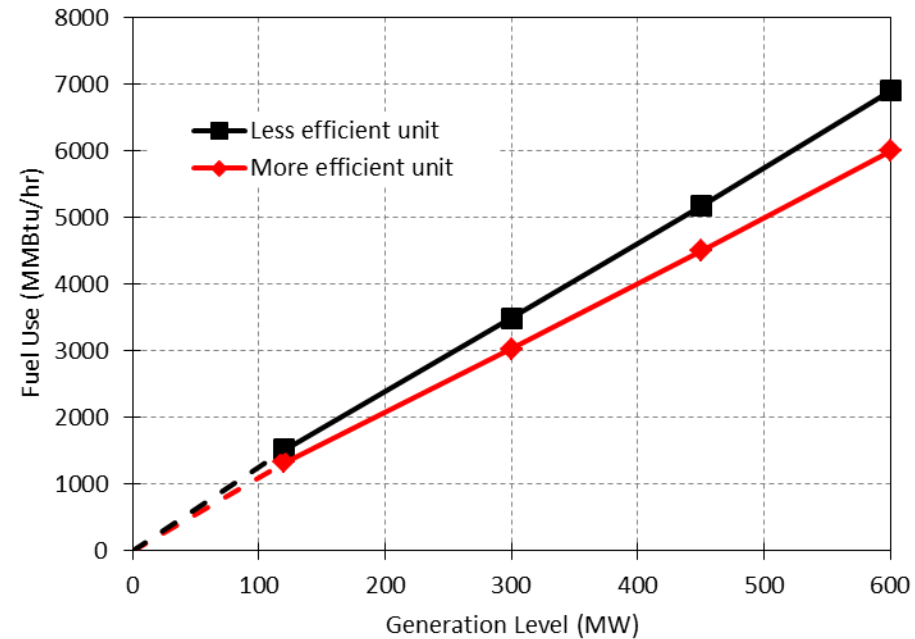


Example Generator Fuel Use Shapes

Oil/Gas ST < 600 MW



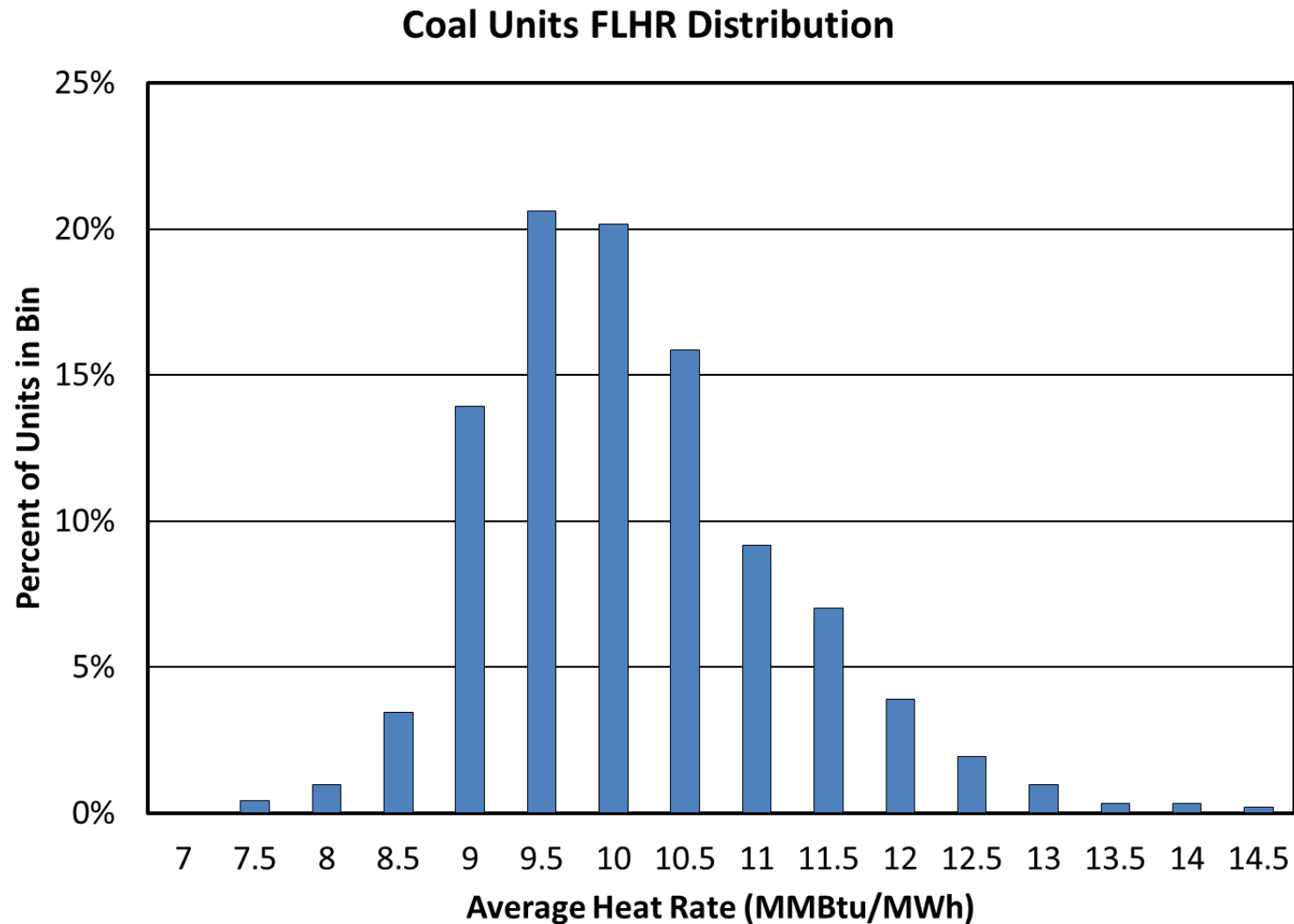
Oil/Gas ST > 600 MW



Average Heat Rates

- **Proposal:**
 - Use CEMS heat rate data where units can be matched
 - Apply distribution of heat rates found from CEMS data where units cannot be matched

Example CEMS Heat Rate Distribution



Planned and Forced Outage Rates

- EIPC used region-specific planned- and forced-outage rates
- We propose to use plant-type-specific rates:

Type	Forced Outage Rates		Forced Outage Repair Time (Hours)	Planned Outage Days/Year	
	EIPC	Proposed	Proposed	EIPC	Proposed
Biomass	5–10%	7.5%	24	18.3–36.5	27
CC	6%	6%	24	24.7–24.7	25
Coal	4–8%	6%	72	25.2–35.3	30
CT	8–10%	9%	24	10.8–15.8	13
Oil/Gas					
Boiler	7%	7%	48	32.1–32.1	32
Hydro	5%	5%	24	0	0
Nuclear	3–7%	5%	168	28.6–28.6	29
PS	0%	5%	24	0	0

Revisions

- **Intertek APTECH Data**
 - Statistical analysis of maintenance costs to quantify relative causes
 - Startup
 - VO&M costs
 - Startup costs 2-3 times EIPC
 - Steady-state VO&M costs lower than EIPC
- **Ramp Rates**
 - EIPC assumption is independent of plant size
 - Revise to % of capacity/minute

Startup Costs

- **Proposal: use startup costs based on lower-bound data from public APTECH report**

Type	Non-Fuel Startup Cost (\$/MW Capacity)	Startup Fuel Type	Startup Fuel Amount (MMBtu/MW Capacity)	Baseload VO&M (\$/MWh)
CT	69	gas	0.9	0.6
CC	79	gas	4.7	1.0
Gas Boiler	86	gas	8.9	0.9
Coal	129	oil	14.5	2.8

Ramp Rates

Type	EIPC Ramp Rate (MW/min)	Assumed Plant Capacity (MW)	Calculated Ramp Rate (%/min)
CT			
CC	10	200	5.0%
Oil/Gas_ST < 600MW	6	75	8.0%
Oil/Gas_ST > 600MW	6	800	0.8%
Coal_ST < 600MW	3	75	4.0%
Coal_ST > 600MW	3	800	0.4%

Type	Calculated EIPC Ramp Rate (%/min)	Proposed Ramp Rate (%/min)
CT	—	8
CC	5	5
Gas Boiler	0.8–8	4
Coal	0.4–4	2

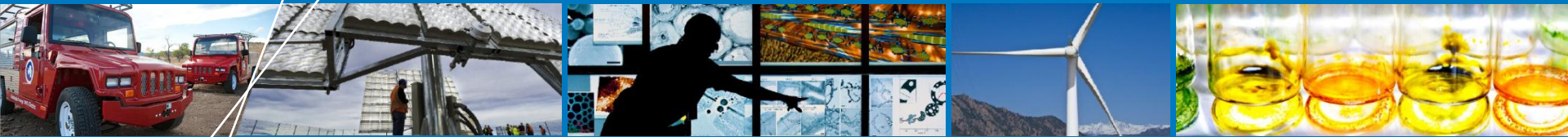
Other Generation Types

- **Characteristics for**
 - Biomass
 - Gas IC
 - Oil-fueled units (IC, CT)
 - Pumped storage
 - Nuclear

Fuel Prices

- **EIA Annual Energy Outlook forecast for 2020:**
 - Natural gas \$4.90/MMBtu
 - Fuel Oil \$22.45/MMBtu
 - Coal \$2.52/MMBtu
- **Fuels not in EIA AEO:**
 - Biomass
 - Nuclear

Generator Aggregation



Generator Aggregation

- **Eastern Interconnect database currently contains:**
 - 7,895 generating units (excluding wind and solar)
 - 3,291 plants
 - 942,485 MW of thermal and hydro capacity

Generator Aggregation

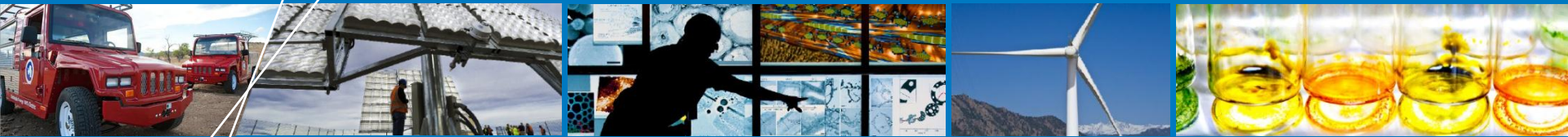
- Aggregate generation units by plant and type

Type	Total Capacity (MW)	Number of Units	Number of Plants	Reduction (%)
Biomass	4,039	130	107	19%
CC	197,822	1,280	457	70%
Coal_ST	316,972	1,229	461	64%
Gas_GT	122,307	1,595	528	68%
Gas_IC	1,432	300	128	57%
Gas_ST	49,947	330	150	55%
Hydro	85,159	1,804	810	56%
Jet_Oil_GT	150	9	8	11%
Nuclear	113,684	122	71	44%
Oil_GT	17,658	464	207	55%
Oil_IC	2,301	394	245	38%
Oil_ST	10,268	112	79	29%
PS	20,666	115	29	75%
Waste HT_ST	78	11	11	0%
Total	942,485	7,566	3,040	60%

Commit Generators

- **Committing generators removes the on/off decision and makes the optimization problem smaller**
- **Little downside if generators:**
 - have very low minimum generation level and minimal startup costs (wind, hydro), or
 - are known to be committed (nuclear)
- **Propose to commit wind, hydro, nuclear by default**

Hydro Properties



Hydro Properties

- **85,159 MW in 1,804 units (810 unique plants)**
- **Minimum generation level?**
- **Economic dispatch vs. scheduled?**
- **Plan to establish monthly energy limits based on EIA generation data for 2006**
 - Approximately 100 plants (1400 MW) are not available in EIA generation data
 - Will need to find a source for the missing energy limit data—ideas?

Thank You

Contact

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